DECLARATION UNDER 37 C.F.R. §1.132

SIR:

I, YASUSHI HASEGAWA, a co-inventor of the above-identified patent application, declare as follows:

1. I am employed by Nippon Steel Corporation, as a senior researcher at the Technical Development Bureau of Nippon Steel Corporation and my employment duties are R & D of ERW pipe and liquid phase diffusion bonding. Fukuju Industry Corporation, Gifu, Japan, is the assignee of the above-identified patent application.

2. I graduated from Tokyo Institute of Technology, Master course in Technical Engineering in March, 1984. I have been employed by Nippon Steel Corporation since 1984. From the beginning of my employment with Nippon Steel Corporation, I have been engaged at the Technical Development Bureau of Nippon Steel Corporation in research with respect to R & D of liquid phase diffusion bonding. I also studied heat resistant steel and liquid phase diffusion bonding at Eidgenosisshe Techinische Hochschule (ETH University) in Zurich, Switzerland from 1993 to 1995.

3. I have read and understand the specification and

claims of the above-identified patent application, I have read and understand the Office Actions and the prior art USP 6,592,154 and USP 6,203,754 applied to reject the claims.

4. The present invention provides a precision machine part, especially a fuel supply valve of an automobile engine, having a plurality of conveyance passages formed therethrough in a direction of the longitudinal axis of the precision machine parts, the precision machine part being configured to permit passage of liquid or gas through said conveyance passages, and being divided along a longitudinal axis thereof to comprise a plurality of pieces, with a transient liquid phase diffusion bonding alloy provided between faces of said pieces to bond the pieces to each other along the faces thereof, said pieces being adhered to each other by a transient liquid phase diffusion bonding process with a ribbon of an amorphous bonding alloy, mainly composed of Fe based amorphous alloy containing 1 to 10 at% of V, and preferably further containing one or more of 1 to 15 at% of B, 0.1 to 10.0 at% of C, 0.1 to 5.0 at% of Si, 0.1 to 2.0 at% of Cr, 0.1 to 1.0 at% of Mo, to form said precision machine part. The fuel supply valve of an automobile engine as mentioned above is typically shown in Figs. 1 and 5.

5. On the other hand, the invention disclosed in the cited reference of USP 6,592,154 relates to a metal-pipe

bonded body, pipe expansion method of a metal-pipe bonded body, and a method for inspecting a metal-pipe bonded body, which comprises a plurality of metal pipes diffusion bonded via a bond interface defined by end portions thereof; wherein a middle portion of said bond interface is inclined with respect to a radius of said metal-pipe bonded body, outer and inner end portions of said bond interface extending parallel to the radius of said metal-pipe bonded body to define flat portions of said bond interface; and wherein the plurality of pipes of said metal-pipe bonded body have undergone a pipe expansion process after being diffusion bonded such that the inner and outer diameters are expanded relative to inner and outer diameters of the pipes prior to being diffusion bonded.

However, the invention disclosed in USP 6,592,154 is quite different from the present invention in the following points.

1) The metal-pipe disclosed in USP 6,592,154 is divided into two pipes in the cross-sectional direction to a longitudinal axis of the pipe.

2) The metal-pipe disclosed in USP 6,592,154 has only one conveyance passage.

3) Even if the metal-pipe is diffusion bonded at the bond

interface which is inclined with respect to a radius of said metal-pipe, the diffusion bond portions are not bonded. The diffusion bonded portion is deformed because a large amount of pressure is applied at a high diffusion bonding temperature of about 1200°C to both pipes in a longitudinal direction and the thinner portions of both pipe end portions to be bonded are greatly deformed.

Therefore, the invention disclosed in USP 6,592,154 has the above-mentioned defects and cannot be applied in actual operation. I found these defects through the following experiments in August, 1996. I explain in detail as follows.

Experiments of a transient liquid phase diffusion bonding in air for a pipe

① Object of experiment

To determine whether a transient liquid phase diffusion bonding process in the air can be applied to an actual steel pipe joint.

② Test piece

- Kind of steel: STK 400 ERW pipe
- Pipe diameter: 267 mm, thickness: 8.9 mm, pipe length: 250 mm
- Joint: Angle of fusion face 45° male and female of the pipe to be bonded. Surface roughness of the

fusion face: about 3 μm

(▽▽▽ surface finishing)

- Amorphous alloy ribbon used in diffusion bonding

  Thickness: about 25 μm

  Shape of ribbon: Same shape as the fusion face

③ Experiment equipment (See: Fig. 1(a), Fig. 1(b) and Fig. 1(c))

- 10 kHz, 50 kW Low frequency emitter, rectifier, heating coil & loader (0.42 MPa) Fig. 1(a) shows a cross-sectional view of the fusion face of the pipe to be bonded. Fig. 1(b) shows a cross-sectional view of the equipment of the actual diffusion bonding operation. Fig. 1(c) shows a perspective of Fig. 1(b).

④ Experiment conditions (Table 1)

Test piece No	Bonding temp.	Bonding load (× 10)	Bonding time	Surface roughness of opening	Initial ribbon thickness
1	1200°C	0.25 MPa	10 min	▽▽▽	30 μm
2	1100°C	0.33 MPa	5 min	▽▽▽	30 μm
3	1200°C	0.33 MPa	10 min	▽▽▽	90 μm

Test piece extracting location is shown in Fig. 2.

⑤ Test results

In case of a fusion face angle of 45°, no bonding area was found at the outer surface of the pipe because of the

fusion face angle as shown in Figs. 3 and 4. Fig. 3 shows the bonding structure in the case of Test piece No. 1 under the conditions described in Table 1. Fig. 4 shows the bonding structure in the case of Test piece No. 2 under the conditions described in Table 1. Bonding efficiency only reaches 60 - 70%. Therefore, the fusion face angle should be changed to 0° (flat fusion face angle in the cross-sectional direction of the pipe).

As shown in Figs. 4 and 5, a steel pipe having the fusion face angle of 45° to be bonded (Fig. 4) was deformed by diffusion bonding at a high temperature of about 1200°C, and a heavy bonding load as shown in Fig. 5.

⑥ Problems caused by diffusion bonding in a steel pipe having an inclined fusion face angle

The steel pipe was extremely deformed at the bonded portion during diffusion bonding operation because of a lower deformation resistance temperature of about 1200°C. If the applied pressure for bonding was increased, deformation resistance was decreased, and also a bonding area was significantly lowered in proportion to an opening area. Accordingly, joint efficiency and joint strength were substantially lowered. Therefore, a desired fusion face angle is 0°.

⑦ Conclusion

The precision machine part having a plurality of conveyance passages according to the present invention is divided into a plurality of pieces in a longitudinal axis of conveyance passages of the pieces. There are no defects caused by deformation because the bonded portion is extended in a longitudinal axis of the divided pieces.

The most significant problem in transient liquid phase diffusion bonding of a precision machine part having a plurality of conveyance passages is accuracy of alignment of the passages to connect each part without deviation of conveyance passages. Fig. 6 shows a general pipe shape of a fuel supply valve of an automobile engine having three conveyance passages, i.e. central passage A for a cylinder, and two other conveyance passages B and C for fuel or cooling medium. It is necessary to avoid a connecting deviation when an upper pipe and a lower pipe are joined by the above-mentioned diffusion bonding. If the pipes are bonded with a connecting deviation as shown in Fig. 6, a piston in the cylinder cannot move, and fuel or cooling medium does not flow. For avoiding these defects, it is conceivable that the pipes can be connected with a fusion face having an inclined angle as shown in Fig. 7, which is similar to the USP 6,592,154 method, for diffusion bonding.

However, this approach may cause defects, as shown in Fig. 8, such as the inner pipe and the outer pipe of the upper pipe being deformed and bent inwardly and the inner pipe and the outer pipe of the lower pipe being deformed and bended outwardly. This phenomenon does not change in case of a pipe having a single conveyance passage. Of course, a pipe

having a plurality of conveyance passages is more difficult to bond than a pipe having a single conveyance passage. Further, in the case of a precision machine part having a plurality of conveyance passages as shown in Fig. 9, it cannot be drilled by way of the USP 6,592,154 method.

The insert material disclosed in USP 6,592,154 and USP 6,203,754 as BNi-3 is a Ni based alloy containing B and Si. However, BNi-3 is an alloy for brazing, not for a transient liquid phase diffusion bonding. If BNi-3 is used as the insert material, the bonded portion is clearly divided into the mother alloy and the bonded metal as shown in Figs. 2(b) and 2(c) of USP 6,203,754. When an amorphous alloy defined in the present invention is used as the insert material, there is no boundary between the mother alloy and the bonded metal, because brazing does not require diffusion. On the other hand, a transient liquid phase diffusion bonding requires the diffusion bonded portion must not be visible. The amorphous alloy to be used as the insert material according to the present invention must contain V in an amount of 1 to 10 at% in the Fe based amorphous alloy.

As described above, the present invention is quite different from the invention disclosed in USP 6,592,154. I believe that there is no prior art regarding a transient liquid phase diffusion bonded machine part, especially a fuel

valve for an automobile engine which is divided into a plurality of parts in the longitudinal axis of the liquid or gas conveyance passages.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

Yasushi Hasegawa

YASUSHI HASEGAWA

[Date] June 2. 2004

Fig. 1(a)

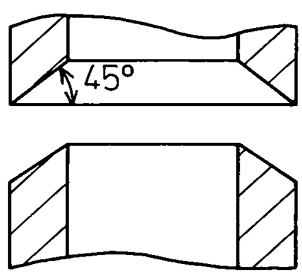


Fig. 1(b)

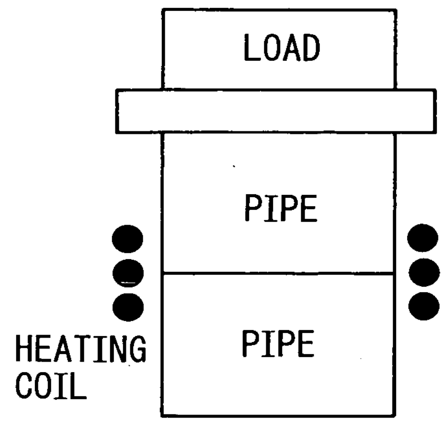


Fig. 1(c)

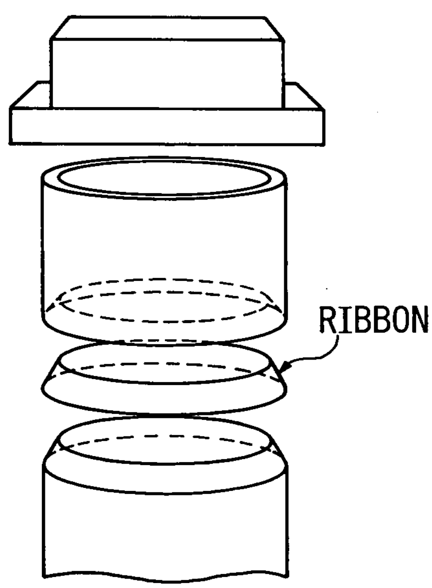


Fig.2

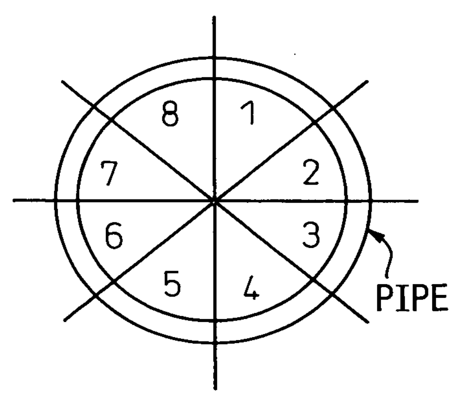
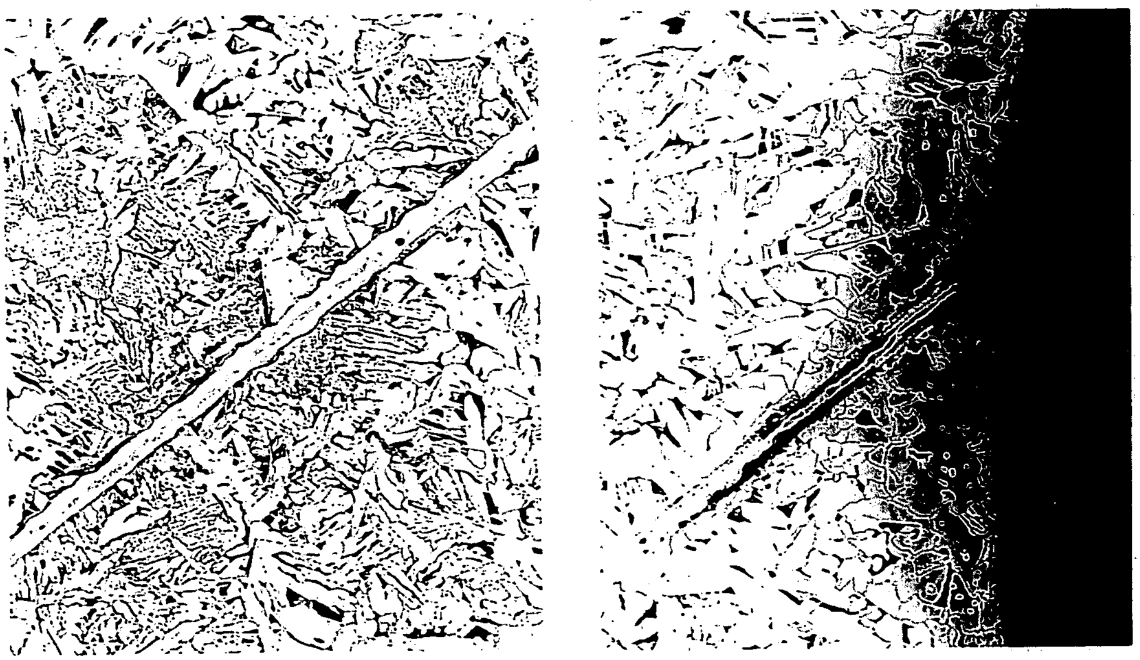
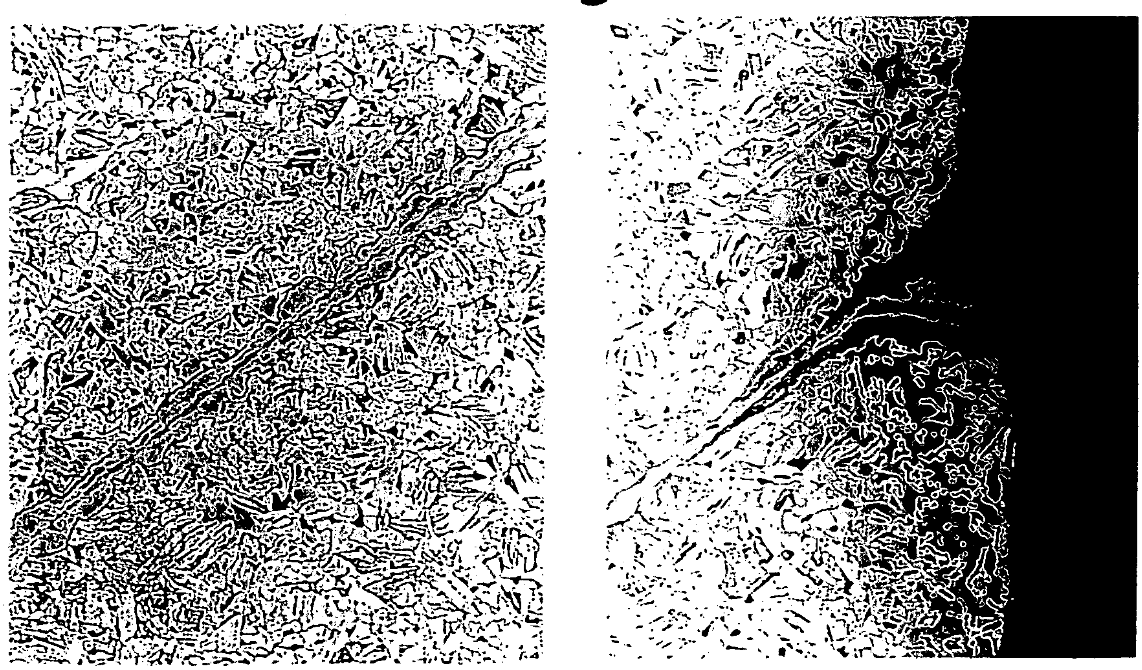


Fig.3



BOND STRUCTURE OF TEST PIECE1

Fig.4



BOND STRUCTURE OF TEST PIECE2

Fig.5

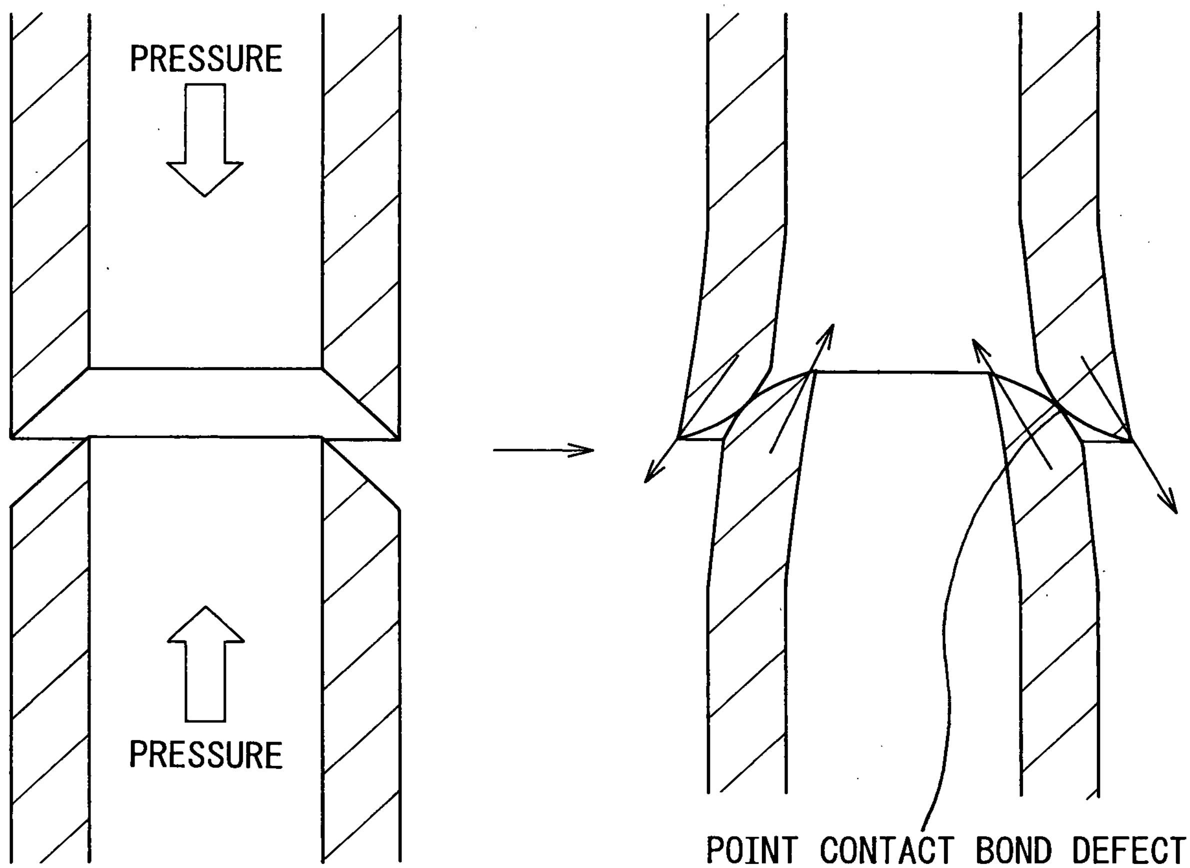


Fig.6

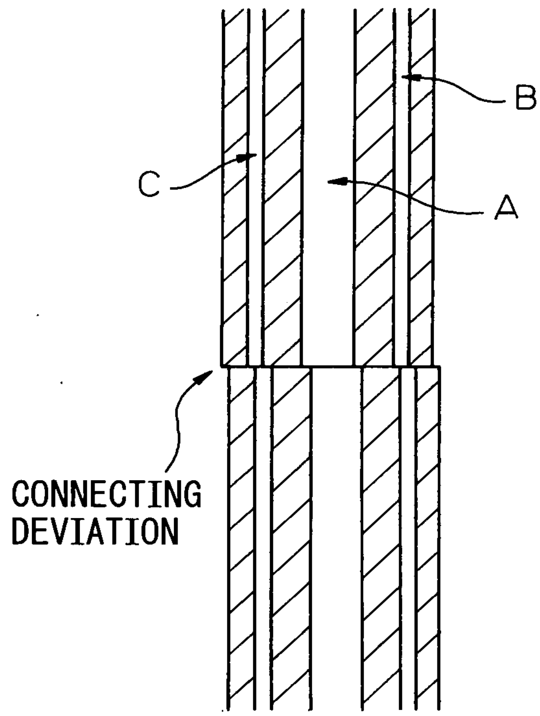

B
C
A
CONNECTING
DEVIATION

Fig.7

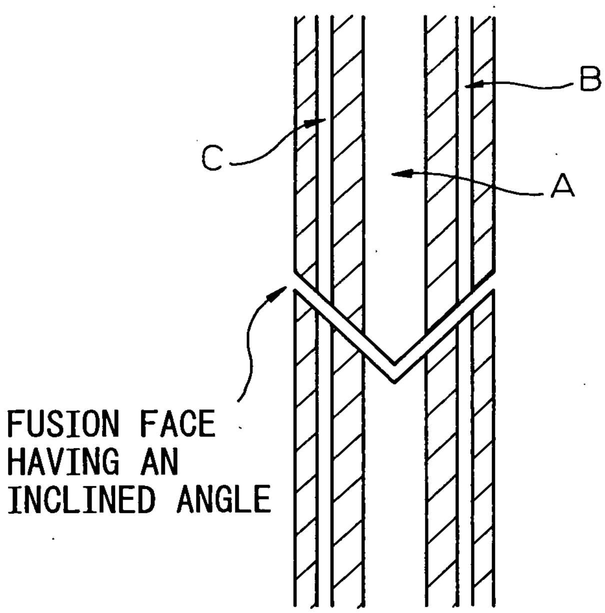

B
C
A
FUSION FACE
HAVING AN
INCLINED ANGLE

Fig.8

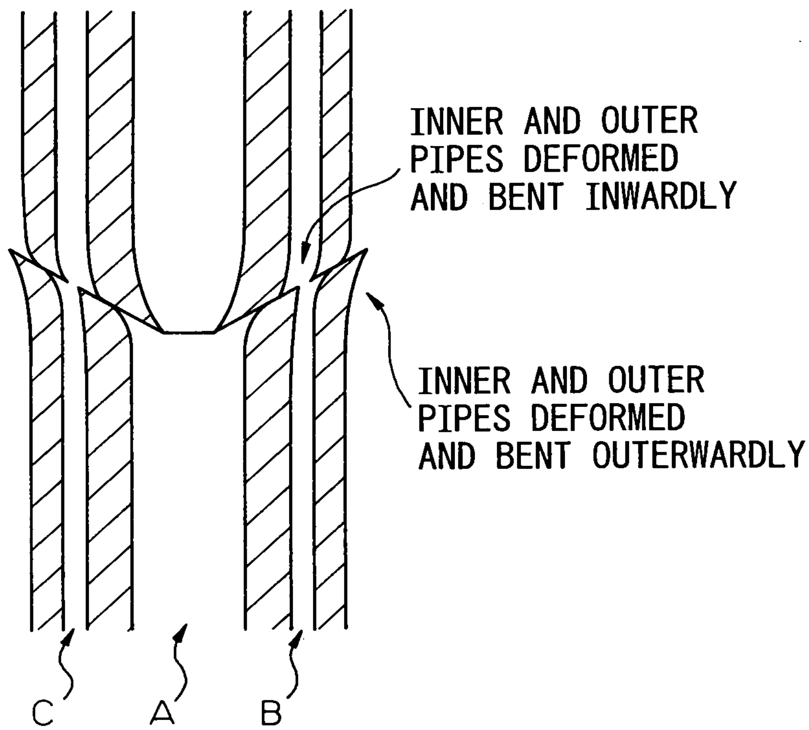
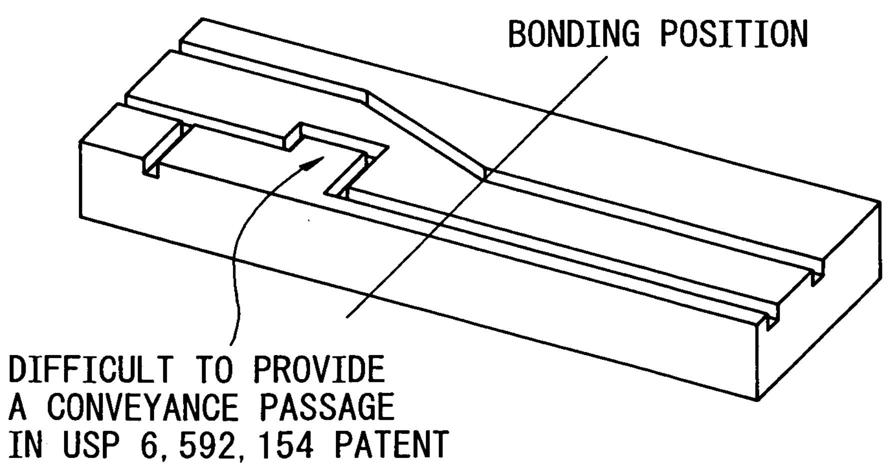

INNER AND OUTER
PIPES DEFORMED
AND BENT INWARDLY
INNER AND OUTER
PIPES DEFORMED
AND BENT OUTERWARDLY
C
A
B

Fig.9


BONDING POSITION
DIFFICULT TO PROVIDE
A CONVEYANCE PASSAGE
IN USP 6,592,154 PATENT